5.3 DAMPERS AND LOUVERS

5.3.1 DAMPER DESCRIPTIONS

By definition, a damper is a device used to control pressure, flow, or flow direction in an air or gas system. See ASME AG-1, Section DA.[63] Different types of dampers can be utilized, depending on specific functional requirements. **TABLE 5.2** below lists the types of dampers and their functions, and **TABLE 5.3** lists the damper configurations. **FIGURES 5.5, 5.6, and 5.7** are examples of industrial-quality dampers. Selection of the proper damper type and blade configuration is important to achieve the required damper performance. The type and configuration of damper can significantly impact pressure drop, leakage rates, and controllability.

Table 5.2 – Classification of Dampers by Function

DESIGNATION	FUNCTION
Flow control damper	A damper that can be continuously modulated to vary or maintain a given level of airflow in the system in response to a feedback signal from the system, or from a signal fed to the damper operator via a manually actuated control or switch.
Pressure control damper	A damper that can be continuously modulated to vary or maintain a given pressure or pressure differential in the air cleaning system or in a building space served by the system in response to a pressure signal.
Balancing damper	A damper set (usually manually) in a fixed position to establish a baseline flow or pressure relationship in the air cleaning system or in building spaces served by the system.
Shutoff damper	A damper that can be completely closed to stop airflow through some portion of the system, or opened partially or fully to permit airflow (the flow control damper may also serve this function).
Isolation damper	A high-integrity shutoff damper used to completely isolate a portion of a system from a contained space, or from the remainder of the system with a leaktight seal. In the case of containment isolation, butterfly valves are used in lieu of dampers.
Back-draft or check damper	A damper that closes automatically or in response to a signal to prevent flow reversal.
Pressure-relief damper	A damper that is normally closed, but will open in response to overpressure in the system or in the contained space served by the system to prevent damage to the system.
Fire and smoke dampers	A damper which interrupts airflow automatically in the event of fire or smoke so as to restrict the passage of flame or smoke through the air system in order to maintain the integrity of the fire-rated partition or other fire-rated separation.
Tornado dampers	A damper that controls airflow automatically to prevent the transmission of tornado pressure surges.

Table 5.3 – Classification of Dampers by Configuration

DESIGNATION	**CONFIGURATION**
Parallel blade damper	A multi-blade damper with blades that rotate in the same direction (AMCA 500).[a]
Opposed blade damper	A multi-blade damper having adjacent blades that rotate in opposite directions (AMCA 500).[a]
Butterfly damper	A heavily constructed damper, often a valve, that is used in piping or duct systems and is usually round in cross-section and designed for high-pressure service (25 psi minimum pressure rating), with one centrally pivoted blade that can be sealed to meet the requirements of Leak Group I (Table 5.5).
Single-blade balanced damper	A damper, usually round in cross-section, with one centrally pivoted blade.
Single-blade unbalanced damper	An accurately fabricated, often counterbalanced damper, usually rectangular in cross-section, with one eccentrically pivoted or edge-pivoted blade.
Folding blade, wing blade, or check damper	A damper with two blades pivoted from opposite sides of a central post that open in the direction of airflow.
Poppet damper	A weight or spring-loaded poppet device that opens when the pressure differential across it exceeds a predetermined value.
Slide or gate damper	A damper similar to a gate valve, with a single blade that can be retracted into a housing at the side of the damper to partially or fully open the damper.

Notes:

[a]AMCA 500-D-98, "Laboratory Methods of Testing Dampers for Rating," Air Moving and Conditioning Association, Arlington Heights, IL, 1998. Also AMCA 500-L-99, "Laboratory Methods of Testing Louvers for Rating", Air Moving and Conditioning Association, Arlington Heights, IL, 1999.

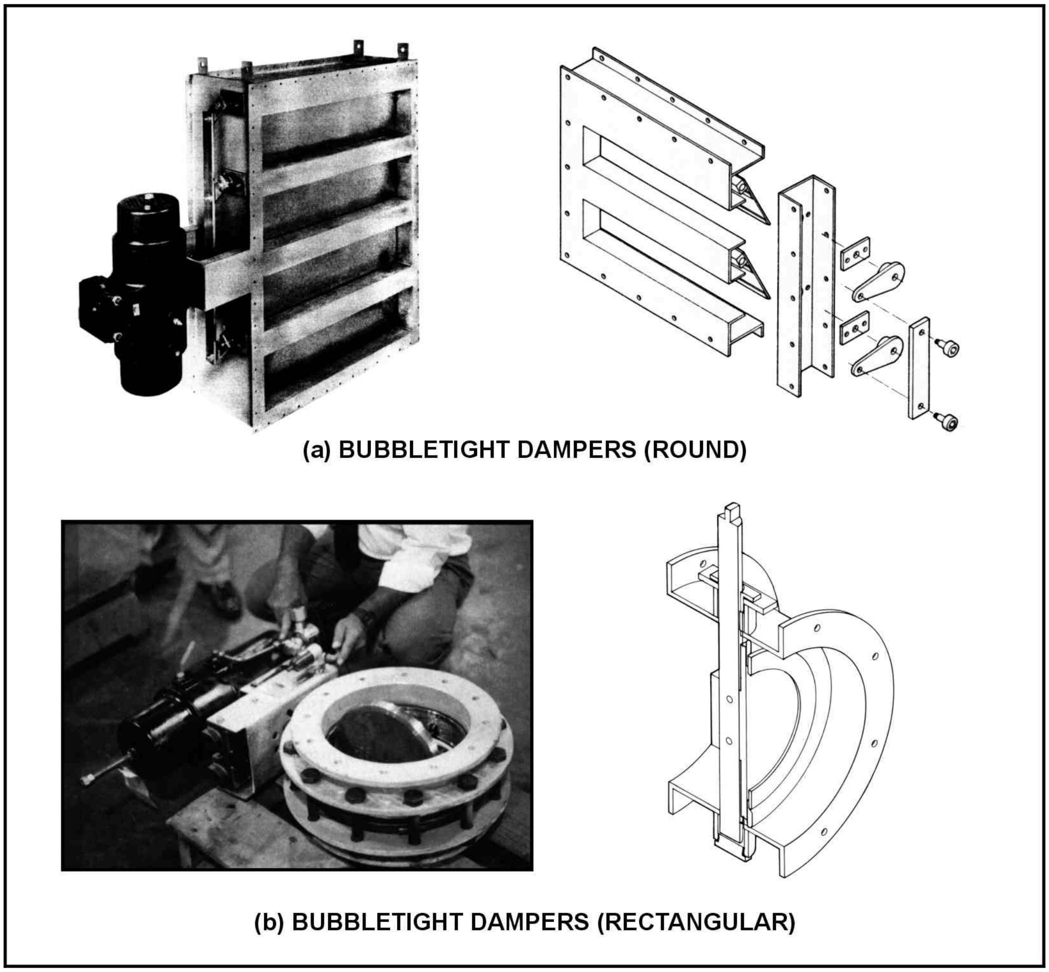

Figure 5.5 – Bubbletight Dampers

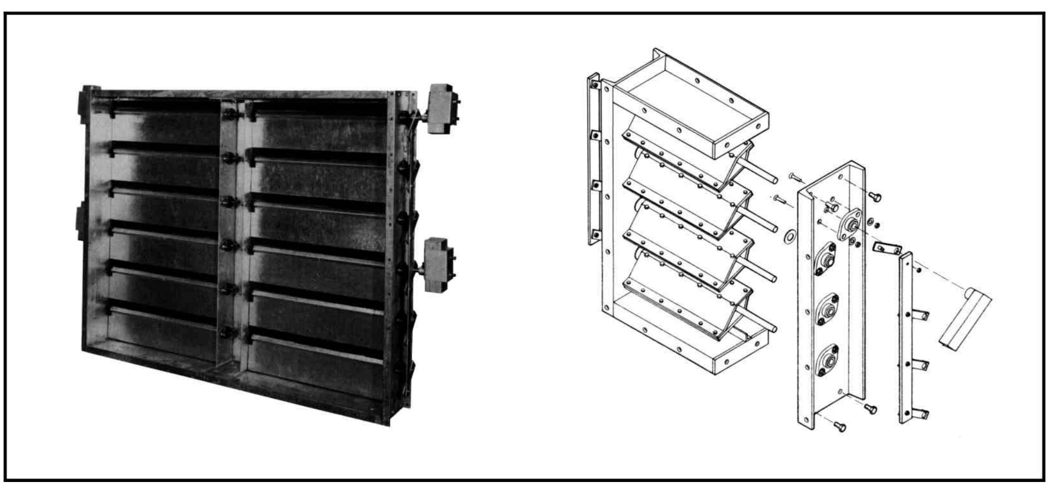

Figure 5.6 – Backdraft Dampers

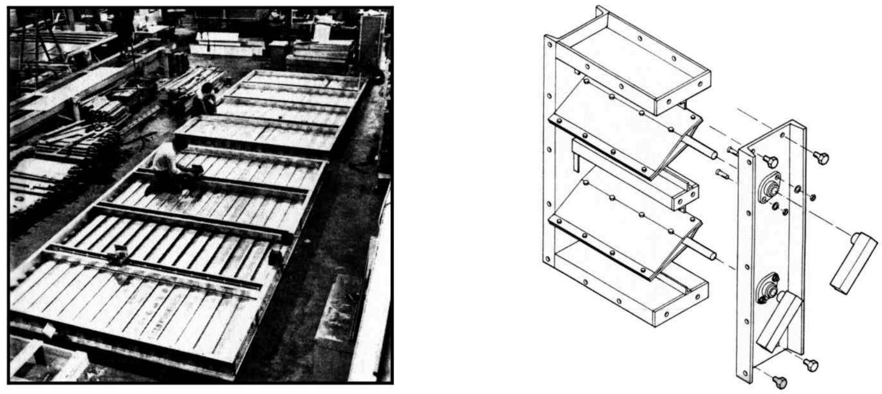

Figure 5.7 – Tornado Dampers

The following factors must be considered in the selection or design of dampers for nuclear applications.

- Damper function
- Construction type
- Dimensions and space limitations
- Pressure drop across closed damper
- Normal blade operating position
- Method of mounting damper
- Blade orientation relative to damper frame
- Operator type and power source
- Seismic requirements
- Requirements for position indicator
- Limit switches and other appurtenances
- Damper configuration
- Permissible leakage through closed damper
- Space required for service
- Airstream environmental parameters (temperature, pressure, relative humidity, etc.)
- Damper orientation in duct
- Airflow direction
- Failure of mode and blade position
- Maximum closing and opening times
- Shaft sealing method

5.3.2 Design and Fabrication

In conventional air conditioning and ventilating applications, damper procurement has been generally accomplished by specifying little more than the manufacturer's make and model number "or approved equal." This is inadequate for nuclear and other potentially high-risk applications. Dampers for nuclear applications should be designed and constructed in accordance with ASME AG-1, Section DA.[63]

Clear, concise specifications must be established for mechanical strength, for leakage rate at maximum (i.e., DBA) operating conditions, and for performance under required operational and emergency conditions. The operability of linkages must be assured through specification of and requirement for cycling at minimum torque requirements under full load. Static testing of the closed damper should be required, where applicable, for those to be used in critical applications to verify strength and leaktightness. All features important to proper operation should be stipulated in detail, including construction materials, permissible lubricants, bearings, blade design and edgings (if permitted), indicating and locking quadrants, supports, operator type and capability, and the accessibility of operators, linkages, blades, and bearings for maintenance.

A checklist of the minimum requirements that must be included in a damper design specification is given in ASME AG-1, Article DA-4110.[63]

5.3.2.1 STRUCTURAL DESIGN

Previous editions of this handbook categorized dampers by construction type. Present construction criteria specified in Section DA of ASME AG-1[63] are categorized by performance requirements (seat or frame leakage, application, function, and loading combinations), as discussed in Section 5.3.3.

The structural design of dampers should be in accordance with Section AA-4000 and Section DA-4200 of ASME AG-1[63] for the loading combinations and the service levels specified in the design specifications. The design should be verified by analysis, testing, or a combination of both for those dampers that must remain functional or retain their structural integrity during a DBE.

5.3.2.2 SPECIAL DESIGN AND CONSTRUCTION CONSIDERATIONS

A very important part of damper design is determination of damper torque and sizing and selection of damper actuator for the maximum torque. Actuator torque should be selected for a minimum of 1.5 times the damper maximum torque to provide margin and allow for degradation over the life of the damper. Actuators should be evaluated for damper blade movement in both directions, at the beginning of blade movement, and while stroking blades through the full cycle of movement.

The linkage mechanism must be designed to transmit actuator torque for the blades to achieve required leakage performance. Ganging of more than two damper sections for operation by one actuator is not recommended because of the potential problems in transmitting the torque equally to each section and blade. Experience has shown that ganging multiple damper sections has led to twisting of drive shafts and overtorquing of the blades closest to the actuator.

Conversely, ganging two or more actuators per damper can also cause operating problems if the actuators are not synchronized. Some blades may close tighter than others, since not all of the blades are linked together. Damper actuators should be factory-mounted whenever possible to ensure design leakage. Wherever actuators must be installed in the field or removed for maintenance, manufacturer's installation instructions should identify the necessary amount of retorquing required to achieve design leakage. The actuator shaft, coupling, and blade shaft should be "match-marked" for easy installation.

Seals are another important component of damper design. Dampers designed for low or zero leakage rely heavily on blade and jamb seals to limit leakage. Seals typically are either metal (e.g., stainless steel) or elastomer. Design of seals should consider the required life of the damper assembly to minimize maintenance. For this reason, stainless steel seals are recommended for low leakage dampers in contaminated air streams whenever possible (see Section DA of ASME AG-1[63]). To control frame leakage, either stuffing boxes or frame cover plates are required.

5.3.2.3 DAMPER OPERATORS

Damper operators can be one of three types, pneumatic, electric, or electrohydraulic, as described below.

<u>Pneumatic</u>. These operators are used whenever controls rely primarily on compressed air (pneumatic) for moving operators or transmitting control signals. Most nuclear facilities only use pneumatic control systems and operators for non-safety-related applications, as the control air is not usually an assured source during DBAs.

<u>Electric</u>. These operators are used whenever controls rely primarily on low voltage electric circuits to transmit control signals and are usually two-position. That is, they are either open or shut and cannot modulate. Most nuclear facilities use electric control systems and operators for safety-related applications because power can be obtained from the assured, Class I electric power and control system.

<u>Electrohydraulic</u>. These operators are the same as the electric type described above, except they have the ability to modulate. Experience has shown that these operators require significant maintenance to keep them functional. They use an electric control signal to position a hydraulic system that, in turn, positions the damper.

5.3.2.4 LIMIT SWITCHES

Limit switches are usually provided directly on the damper to detect the open and closed position of the damper blade. The switches are housed in enclosures defined by NEMA 250.[69] The contact rating must be properly selected for the electrical load. The force required to operate the limit switches must be considered to properly size the damper actuator.

5.3.3 PERFORMANCE REQUIREMENTS

The dampers for nuclear air cleaning systems must be designed to meet the following required performance requirements.

- Seat leakage
- Frame leakage
- Pressure drop
- Closure (or opening) time
- Fire rating and closure

Seat and frame leakage must be in accordance with ASME AG-1, Section DA,[63] Mandatory Appendix DA-I for Leakage Class O (Zero), I (low leakage), II (moderate leakage), III (normal leakage), and IV (applications where leakage is of no consideration). Seat leakage class should be determined by the engineer based on radiological and health physics analysis and known or estimated airborne concentrations within the duct system. Frame leakage is also based on radiological assessments of the effect of airborne concentrations inside and outside the ductwork, as well as the system configuration. For further guidance on leak class determination, refer to ASME AG-1 Code, Section DA.[63]

Pressure drop of the damper has an important impact on proper system operation. Dampers with high-pressure drop, especially for counterbalanced pressure relief dampers, may restrict airflow and affect space pressurization. The pressure drop characteristics of dampers as a function of airflow rate or velocity indicates the ability of each particular type of damper to control airflow. Preferably, the pressure drop/airflow characteristic should be as close to linear as possible to achieve controllability. Opposed blade damper pressure drop characteristics make this type of damper well suited for flow or pressure control compared to parallel blade or butterfly dampers.

For fire dampers installed within duct systems where the airflow normally flows continuously and the damper must isolate portions of the duct system in case of fire, the damper must be designed for closure under airflow. This requirement has caused difficulties with past damper construction. Recent tests have shown that different manufacturers'[67] dampers react differently based on their particular design. Some dampers are sensitive to air velocity. **FIGURE 5.8** shows the maximum velocity at which a manufacturer's damper can close as a function of damper size. **FIGURE 5.9** shows that some dampers are more sensitive to duct pressure upstream of the damper when it is closing.

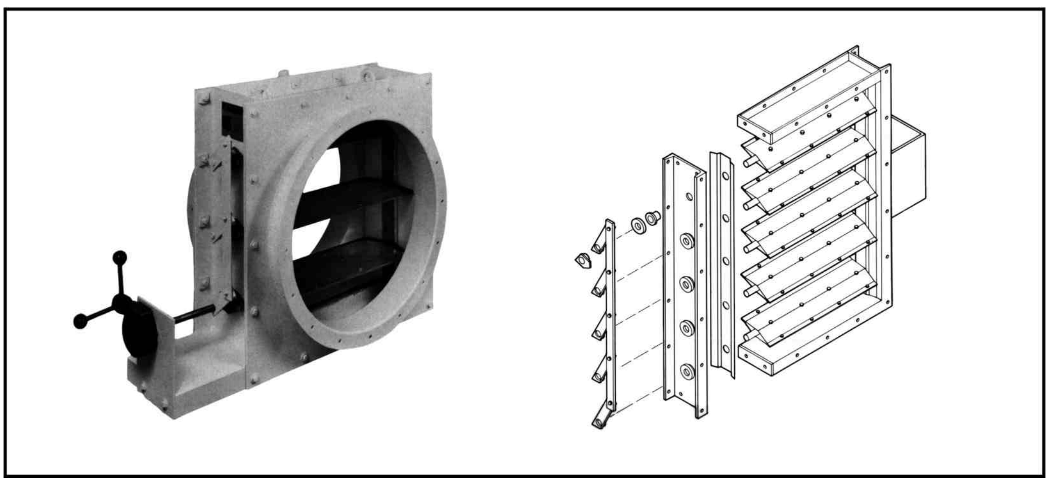

Table 5.8 – Shutoff Dampers

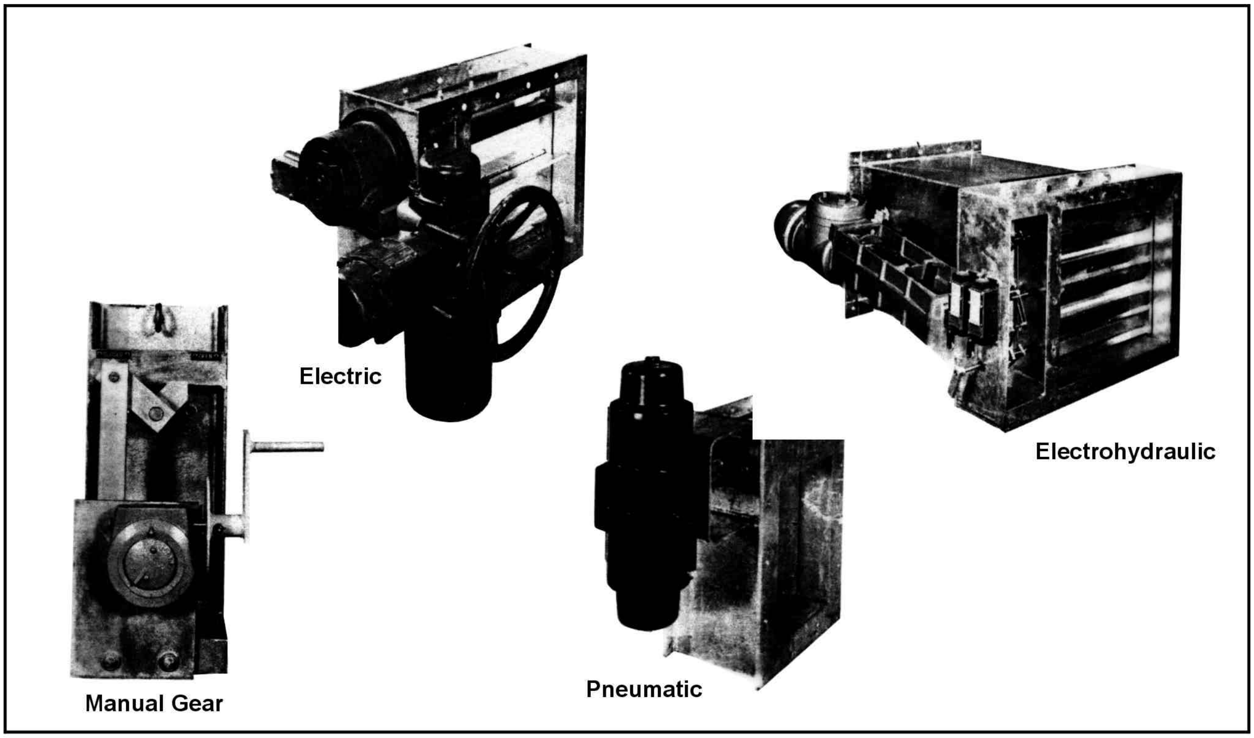

Figure 5.9 – Actuator Options

5.3.4 QUALIFICATION TESTING

Qualification consists of performing prototype or pre-production-model tests to verify the design, performance, and operational characteristics of the dampers. In the case of AMCA-rated dampers, these tests essentially consist of pressure drop and airflow determinations at various degrees of blade opening. The AMCA rating is generally considered sufficient evidence that suitable qualification tests have been done. For dampers not listed by AMCA, the manufacturer should be required to provide performance data obtained under conditions equivalent to those used in the AMCA 500-D[24] test standard. One particularly important piece of information that can be obtained by qualification testing is the resistance of the fully open damper and the resistance versus blade-position curve from full open to full closed. Resistance must be included in the air cleaning system design calculations in the same manner as other system resistance. Qualification tests must be performed prior to fabrication and, if possible, prior to award of a contract.

Production units should be subjected to acceptance tests to verify that the units are in good operating condition and to document their ability to meet performance requirements such as leakage and closure time. Repetition of other qualification tests to demonstrate operational characteristics is generally unnecessary and unwarranted. Dampers should be cycled through the full range at least 10 times, with all accessories attached, to verify the free and correct operation of all parts and the correct adjustment, positioning, and seating of the blades. Maximum time for operation of any of the cycles should be not more than the specified cycle time. Limit switches, if used, should be checked for proper operation. Adjustments should be made as necessary during the test to correct deficiencies. Shop leakage tests for seat and frame leakage should be performed when applicable. Seat leakage testing should be performed after cycle testing is completed. Tests should be performed in accordance with ASME AG-1, Article DA-5000, "Inspection and Testing."[63] Because damper operators are generally furnished to the damper manufacturer as a purchased item, a test to verify the torque characteristics of the operator is desirable after installation of the damper in its service position, particularly for control, shutoff, and isolation dampers for all ESF dampers.

Fire dampers must be qualified for closure under airflow by testing in accordance with AMCA 500-D[24] for both plenum-mounted and duct-mounted configurations. The damper must close completely at maximum airflow rate for various sizes of dampers and for maximum static pressure. Fire and smoke dampers must be tested in accordance with UL-555[70] and UL-555S,[71] respectively, when dampers are required in fire- or smoke-rated barriers.

5.3.5 LOUVERS

The function of louvers is to keep rain, snow, and trash from being drawn into outside air intakes for air handling systems. They can be either fixed-blade or movable-blade design. The vast majority of louvers are of the fixed-blade type. If shutoff or modulation of the air stream is necessary, dampers can be used downstream of the louvers. If operable louvers are used and shutoff or modulation is required, then an operator is required (see Section 5.3.2). Architects usually are consulted when specifying louvers because the louvers are located on outside walls or roofs and should blend in with the architectural features of the structure.

It is important to account for the amount of area that the louver blades take up when sizing the louvers. Blades typically take up 50 percent or more of the free area that affects the velocity of the air entering the intake. The usual maximum velocity to prevent water and snow entrainment in the air stream <u>is less</u> than 500 fpm. Therefore, if 1000 cfm of air is being drawn into an intake and the louvers take up 50 percent of the free area, then the square footage of the opening required is:

1000 ft^3/min x 1/500 ft/min x 1/50 percent = 4.0 ft^2 opening required

In addition to the free area and velocity considerations, the pressure drop of the intake louvers must be included in the system pressure drop calculations.

For louvers on exhaust openings, the velocity is not usually a primary concern, with the exception that the higher the velocity, the higher the pressure drop that has to be accounted for in the system pressure drop calculations.

Finally, louvers must meet the same structural requirements as the rest of the air cleaning system. That is, they must meet the seismic loading requirements if they are required to function during and after a DBA.

Louver testing must conform to AMCA 500-L[43]

5.4 FANS AND MOTORS

The selection of fans and motors for air treatment systems is a very important part of the design of the systems. An air cleaning unit may be properly designed and arranged, the duct system may be nearly leak-free, dampers may be properly constructed, and controls may be functioning correctly, but if the fan is not sized and selected properly, then the system will not perform its design function. For example, the system resistance must be correctly calculated, the effect of parallel or series fans must not result in surging, and the fan must be selected for the applicable range of airflow and pressure. ASME AG-1, Article BA-4110,[63] contains a list of the design parameters necessary to properly specify and/or select a fan and motor.

This section will review the types of fans commonly used in air cleaning systems, guidance on proper fan sizing, fan arrangement, connection to duct systems, leakage, mounting, and qualification testing. All of these factors must be considered when designing, selecting, and installing these fans.

5.4.1 FAN TYPES AND APPLICATIONS

Fan types can be classified as centrifugal, Vaneaxial, and high-pressure blowers. Centrifugal fans can be further classified by blade type as airfoil, forward curve, radial, and backward inclined/backward curved. Vaneaxial fans can be classified as either fixed or adjustable pitch. Typical fan curves for each of these fan/blade types are shown in **FIGURE 5.10**. All fans can be furnished as either direct or belt drive. Note that, for nuclear power plant applications, fans located inside the containment are usually direct drive to minimize the maintenance and adjustments associated with belt drives (because containment entry is limited).

Many nuclear cleaning systems differ from conventional HVAC systems in that they usually are high-pressure systems (greater than 10 in.) and could be low-flow (3,000 cfm) or high-flow